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Harbers, Jr.

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(54) **HIGH EFFICIENCY BELAY APPARATUS**

(75) Inventor: **Henry C. Harbers, Jr.**, Templeton, CA (US)

(73) Assignee: **Atoll Holdings, Inc.**, San Luis Obispo, CA (US)

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- 1,123,776 A 1/1915 Meyer
- 1,766,566 A 6/1930 Tucker
- 1,787,651 A 1/1931 Zwink
- 4,039,045 A 8/1977 Hoger
- 4,645,034 A 2/1987 Griffith
- 4,679,656 A 7/1987 Lew et al.
- 4,941,548 A 7/1990 Blanchard
- 4,997,064 A 3/1991 Motte et al.
- 5,186,275 A 2/1993 Bajin

Primary Examiner—Alvin Chin-Shue
(74) *Attorney, Agent, or Firm*—William W. Haefliger

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- (51) **Int. Cl.**⁷ **A62B 35/00**
- (52) **U.S. Cl.** **182/231; 182/7**
- (58) **Field of Search** **182/231, 236, 182/7**

(56) **References Cited**

U.S. PATENT DOCUMENTS

- 421,115 A 2/1890 Taylor
- 441,819 A 12/1890 Bresnahan
- 662,243 A 11/1900 Nelson
- 1,113,369 A 10/1914 Olson

(57) **ABSTRACT**

Apparatus for use in controlling vertical movement of a first weight, comprises a first element rotatable in one direction about an axis and blocked against rotation in the opposite rotary direction; a second element acting as a guide; a control weight; and lines supporting the first weight and control weight by the elements, and including a first line wrapping about the first element and a second line entraining the second element, whereby changes in force exertion on the control weight determine alternative existence of a first mode of operation wherein line slippage relative to the first element allows the first weight to descend, and a second mode of operation wherein line non-slippage relative to the first element thereby blocks descending of the first weight. In addition, the control weight is usable to exert force acting to remove slack from the second line, which is important for safety reasons, where the apparatus is used for climbing. Governor, hoist and other safety elements may be employed. A climbing pole is also provided for use in climbing in conjunction with operation of the elements, control weight and lines.

39 Claims, 12 Drawing Sheets

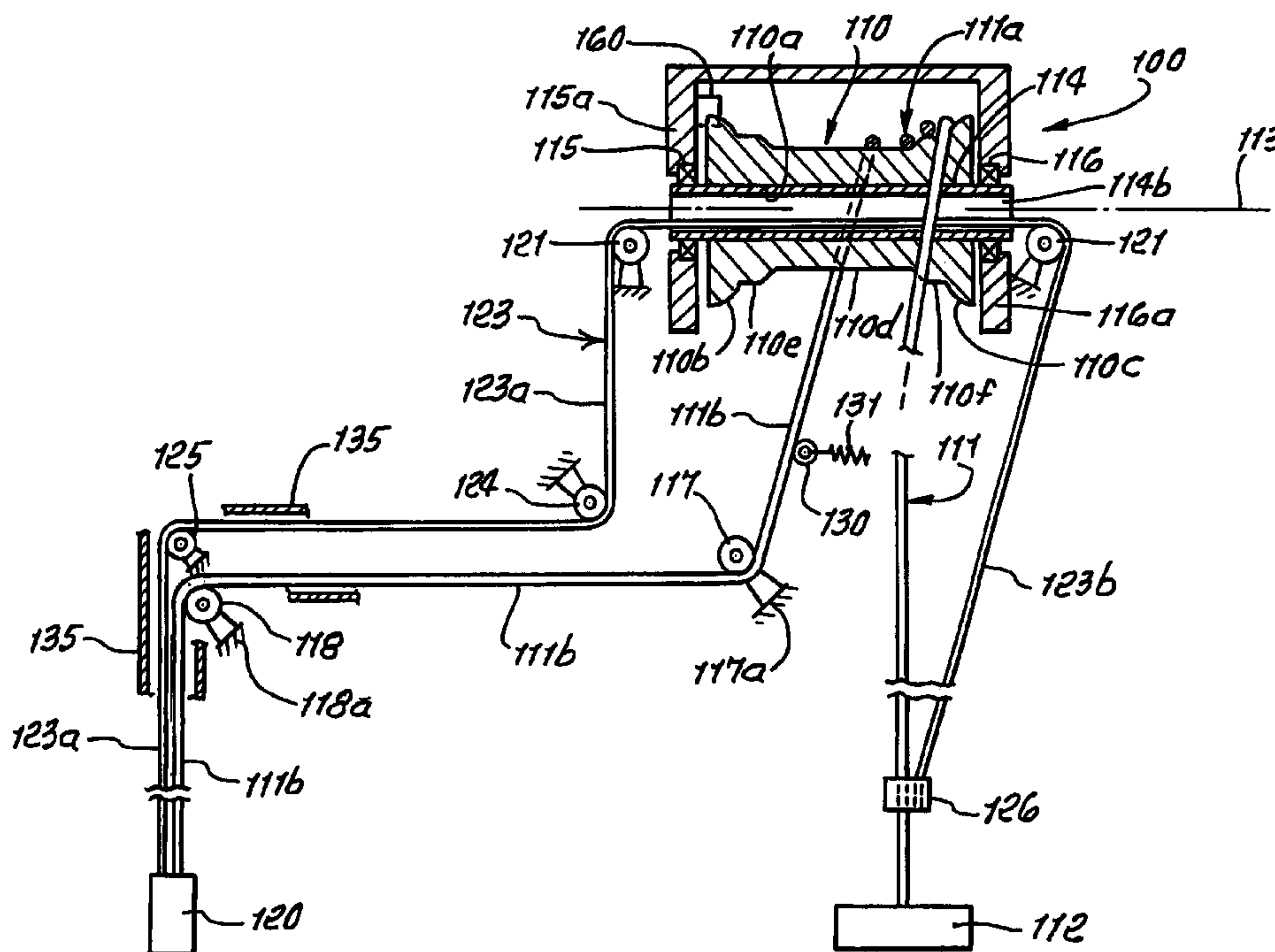
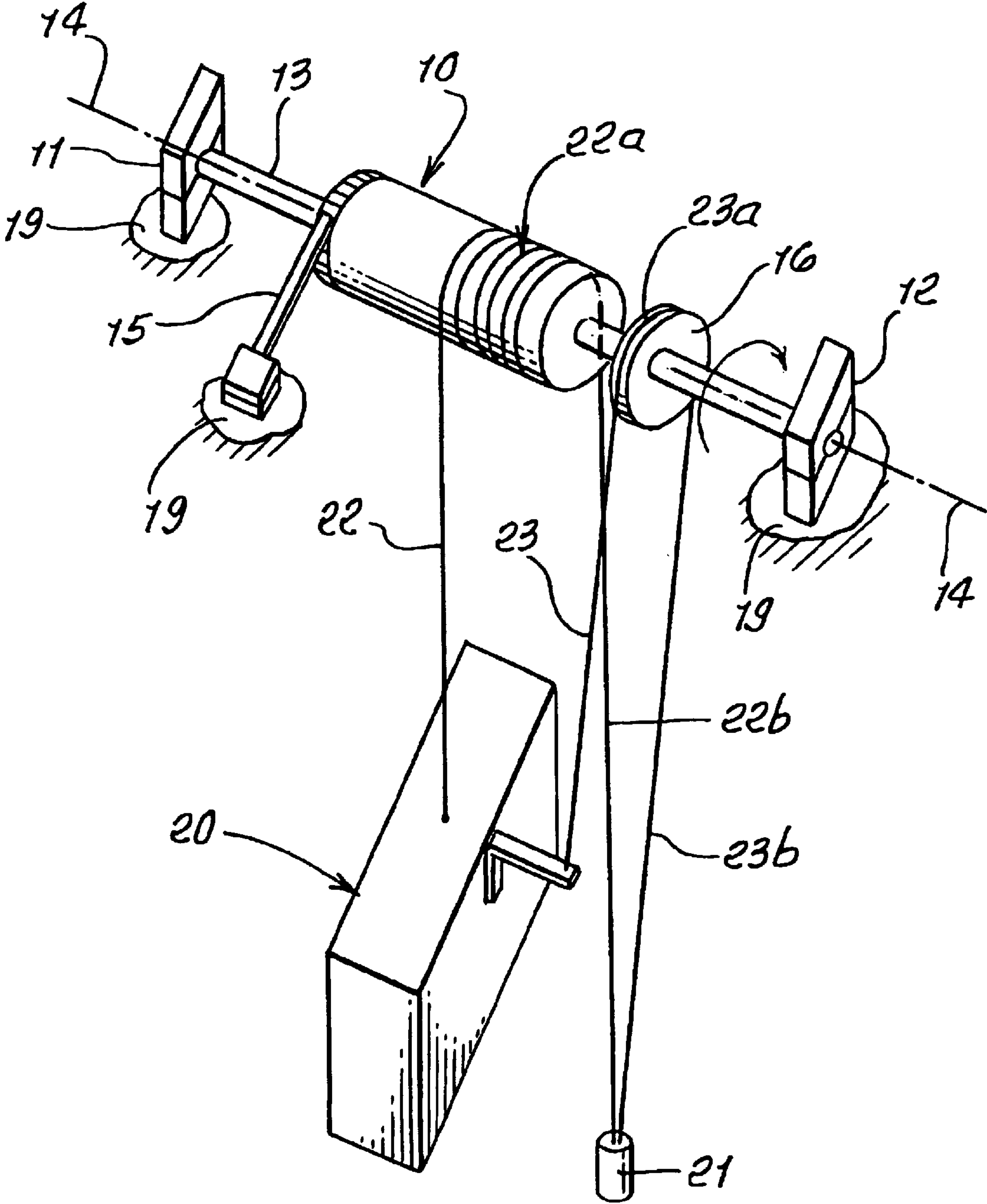


FIG. 1.



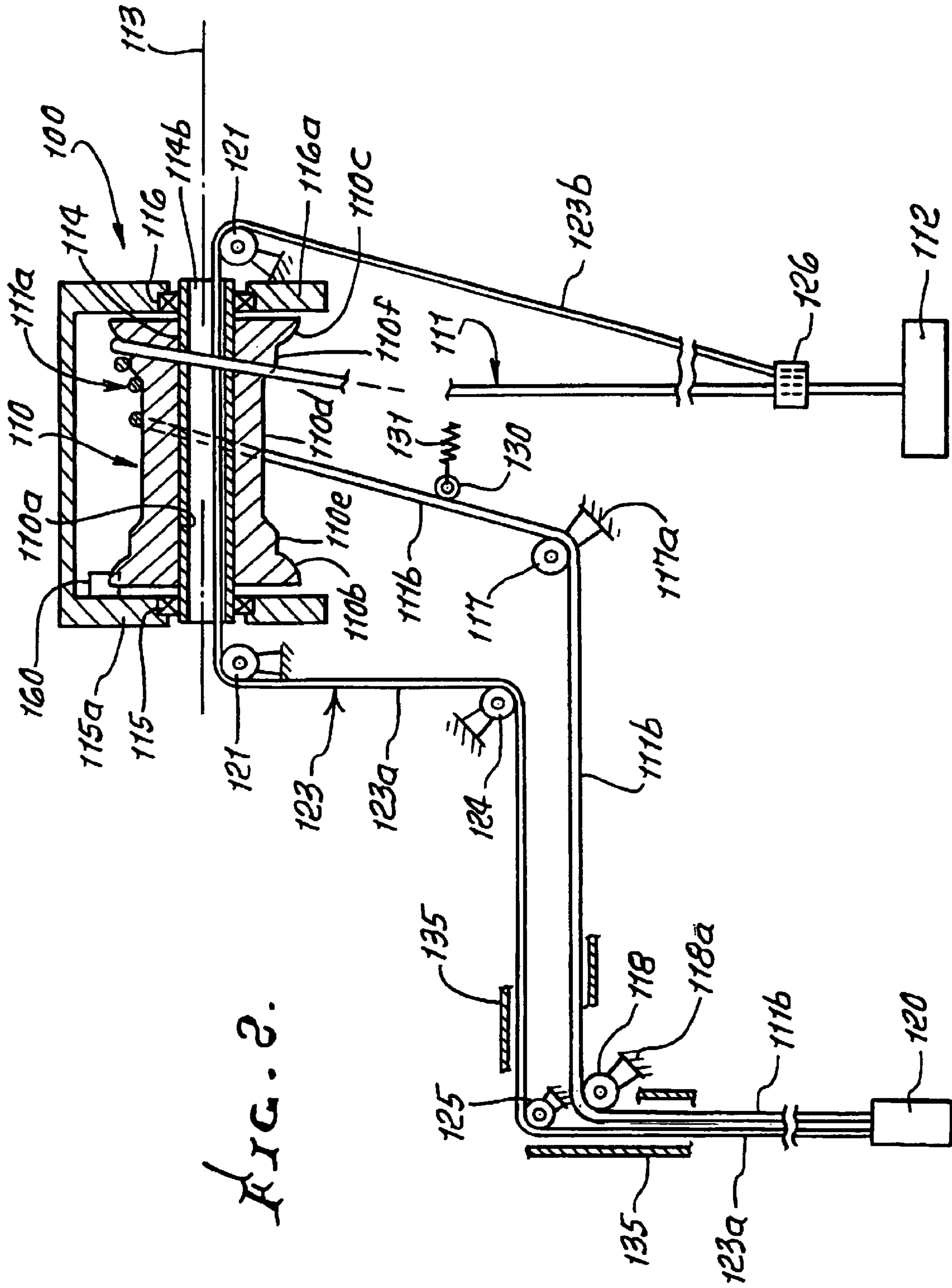
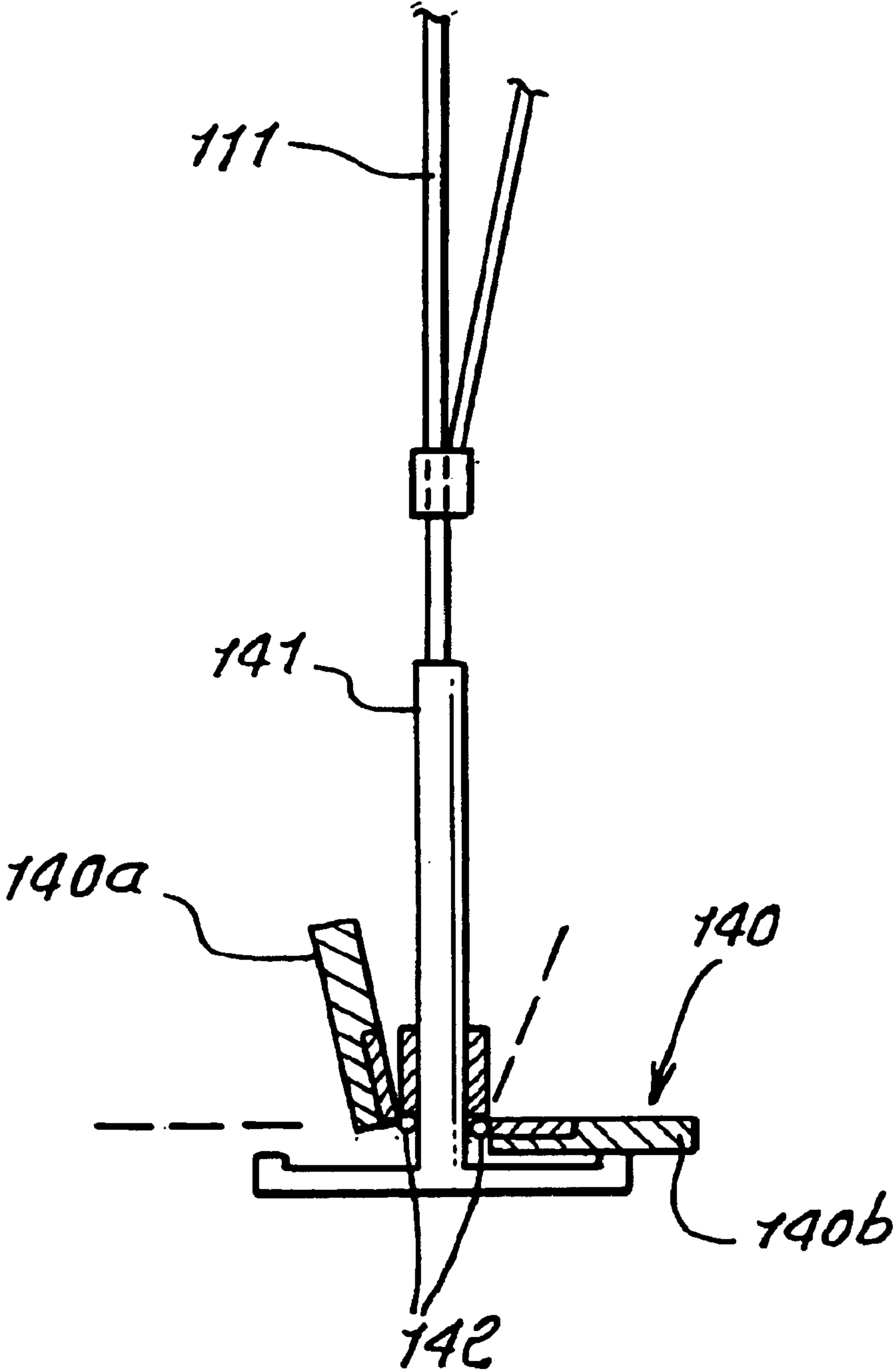


FIG. 2.

FIG. 3.



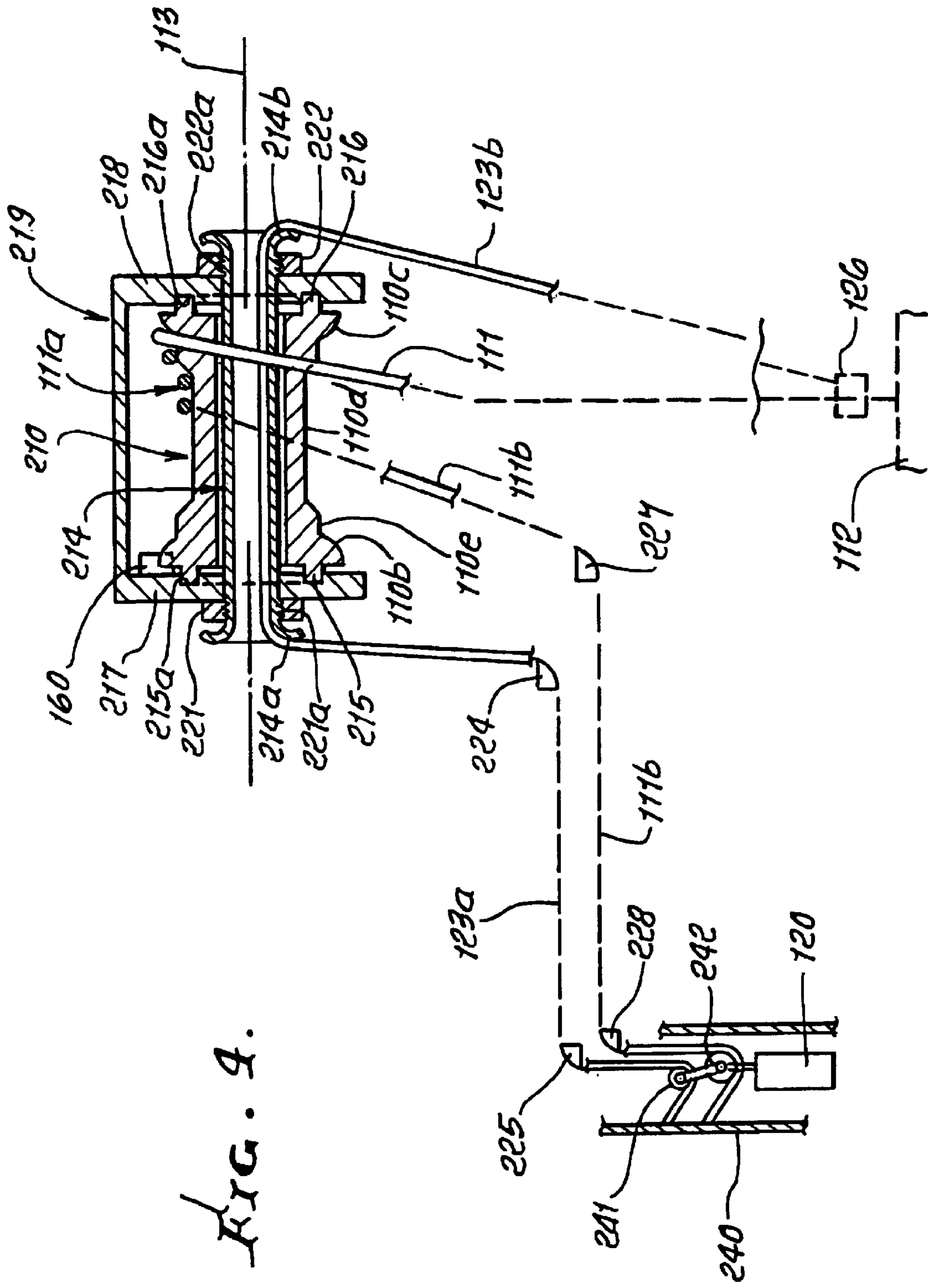


FIG. 4.

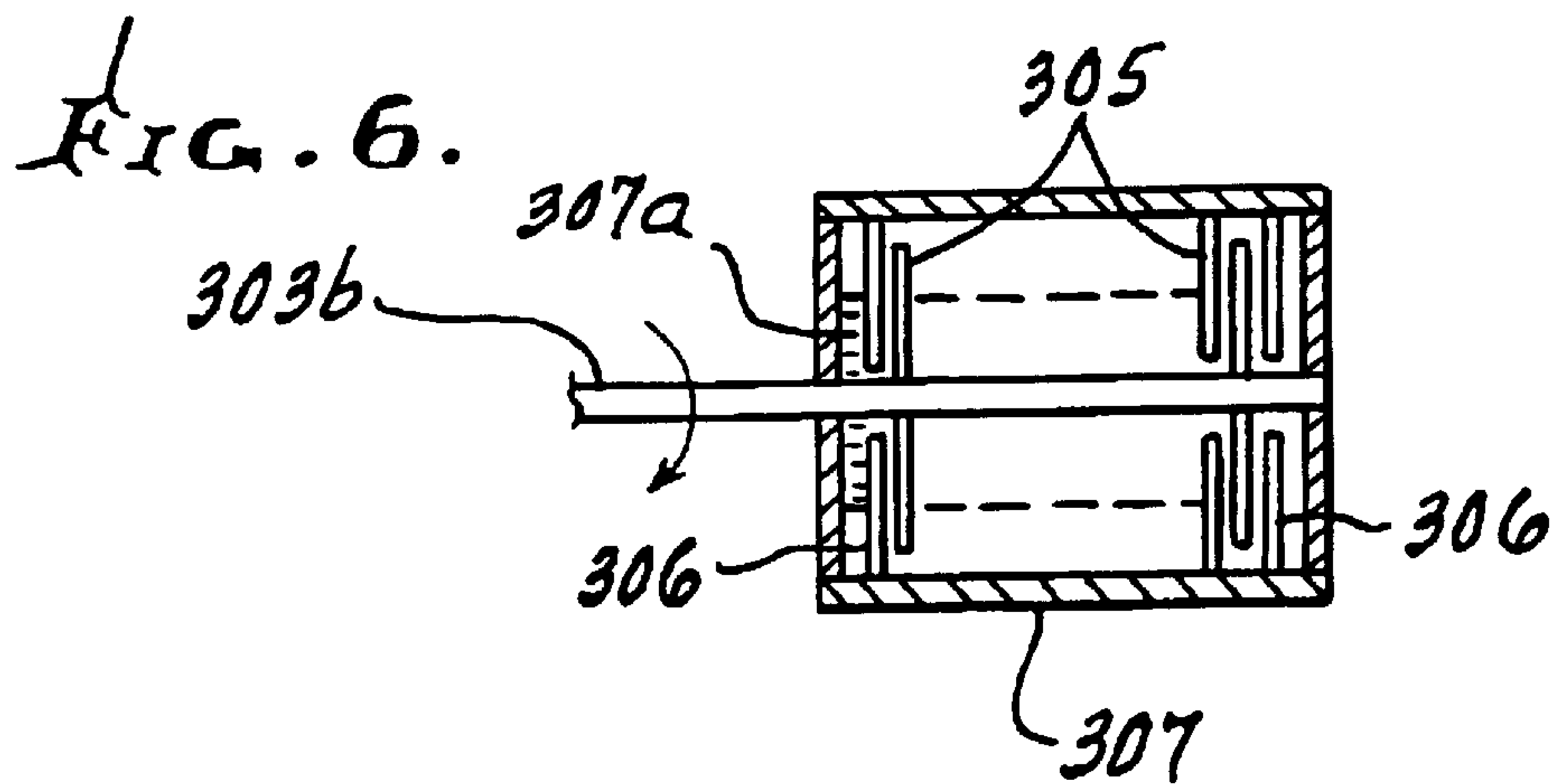
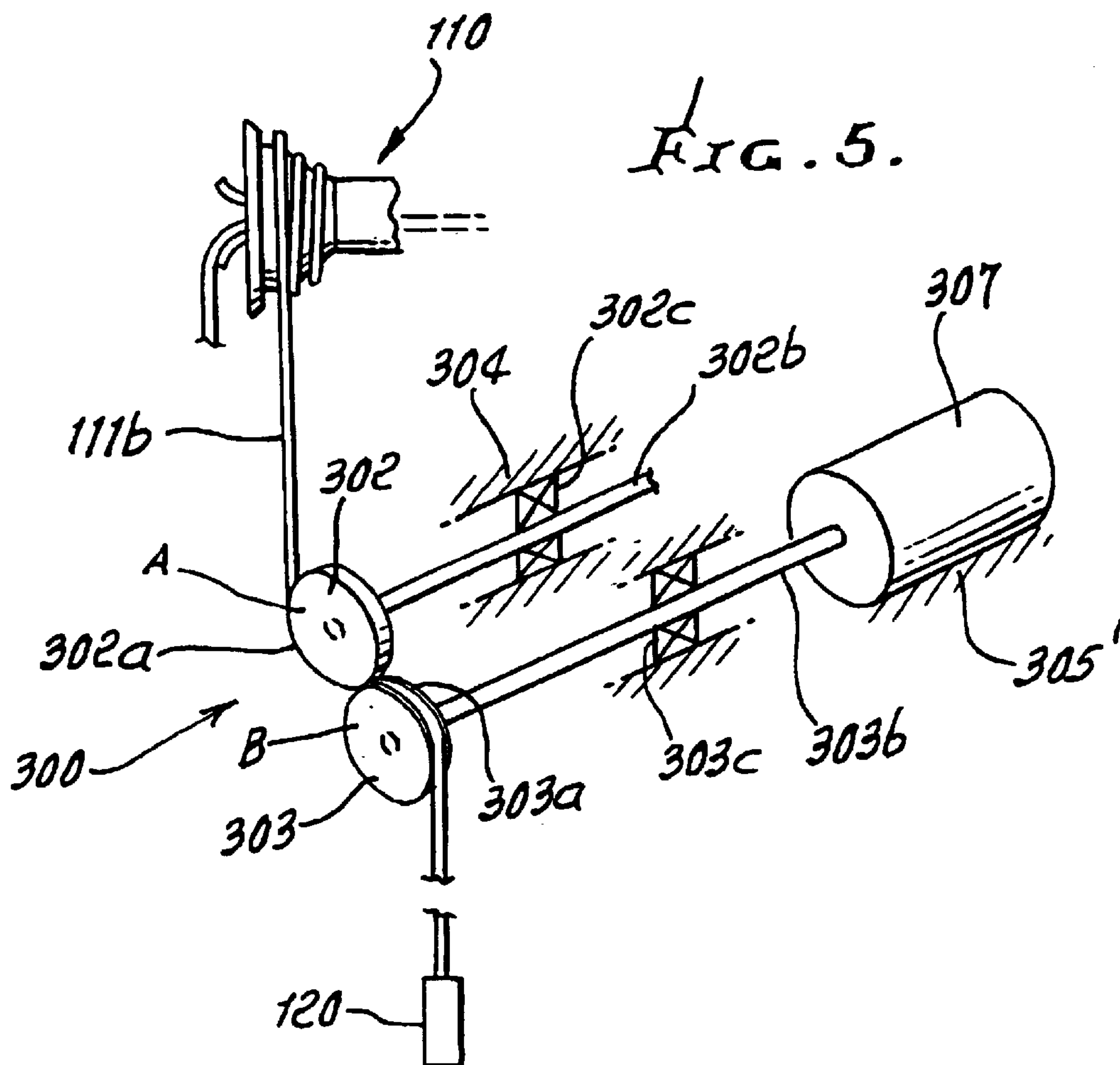


FIG. 7.

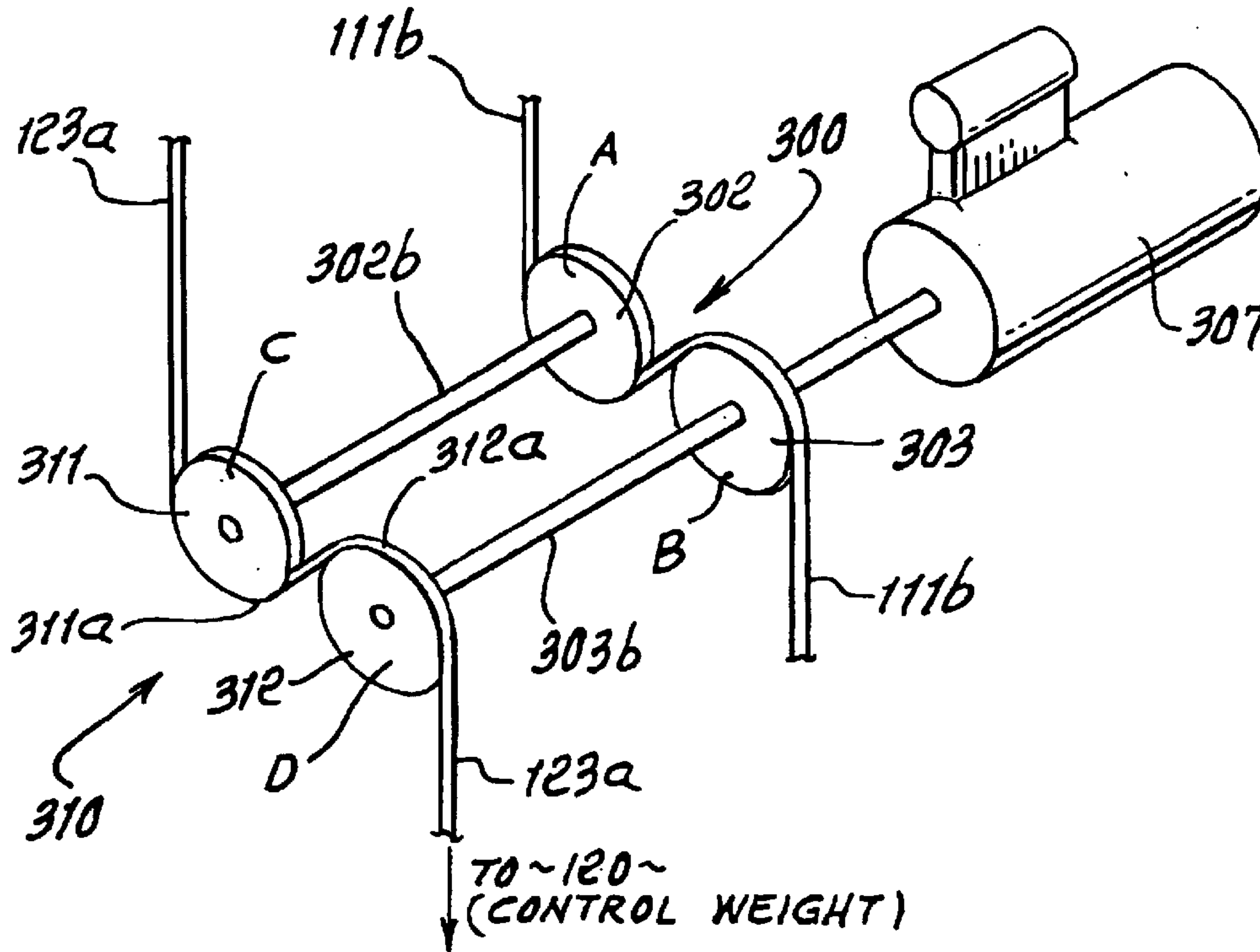
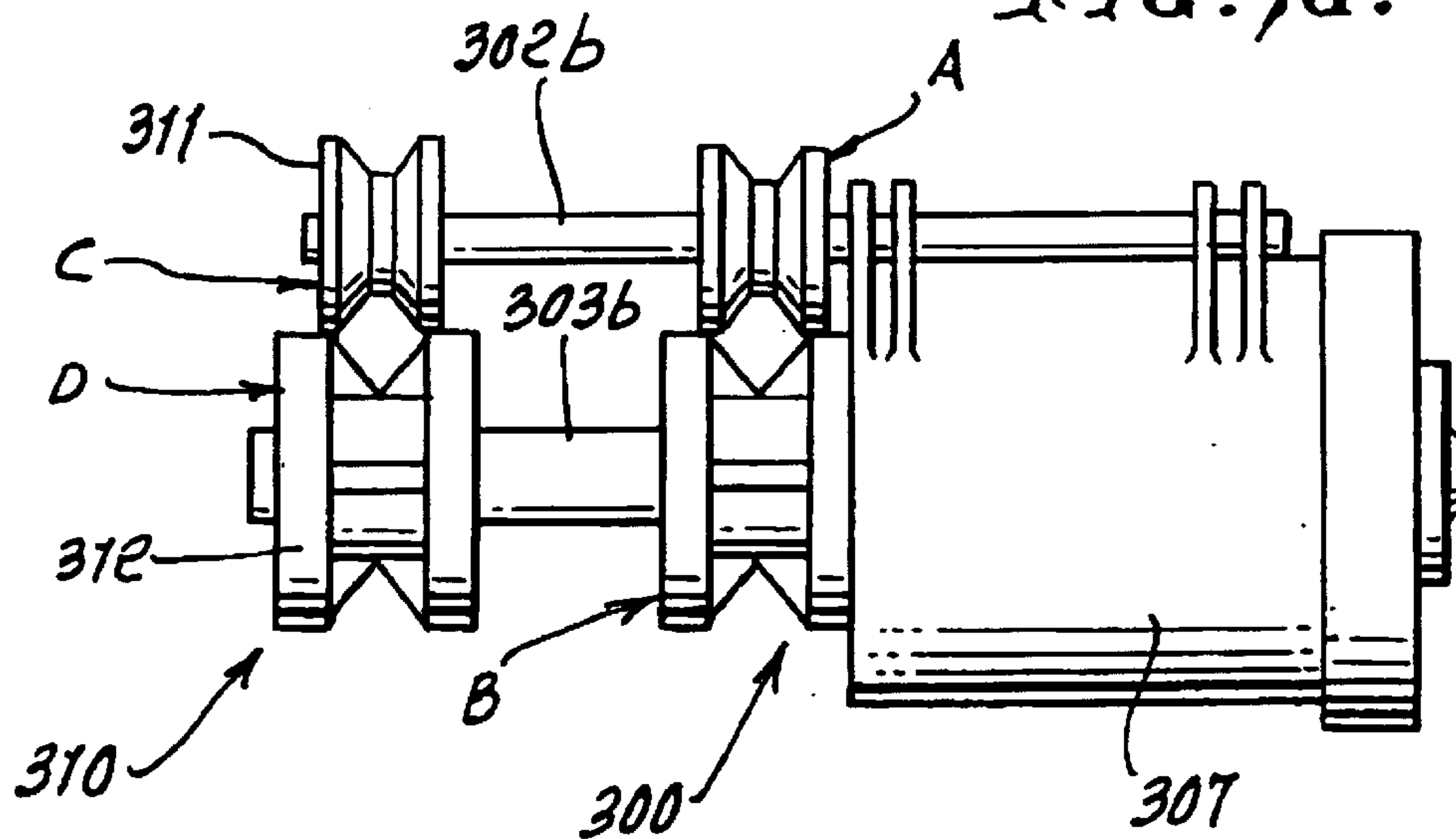
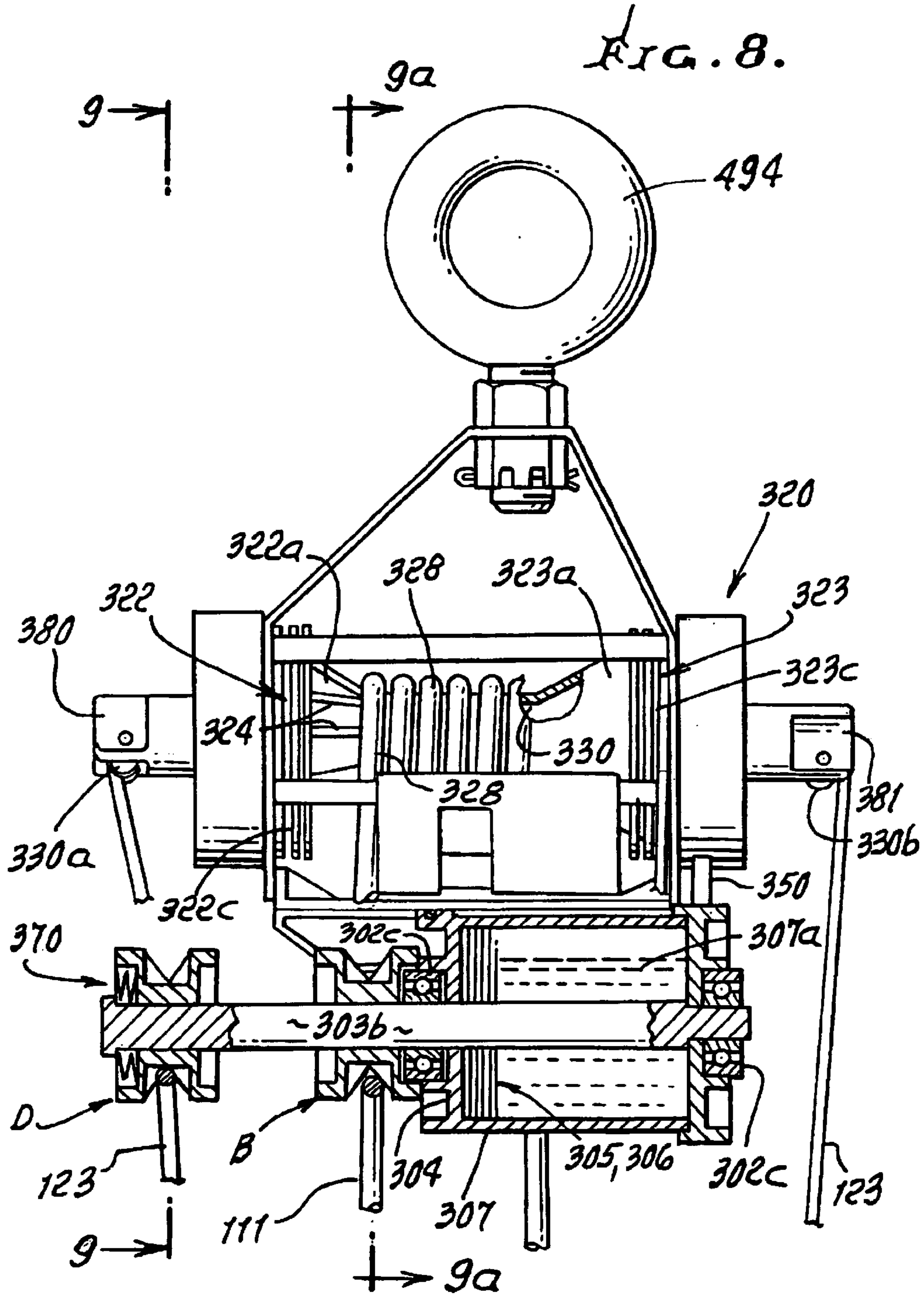


FIG. 7a.





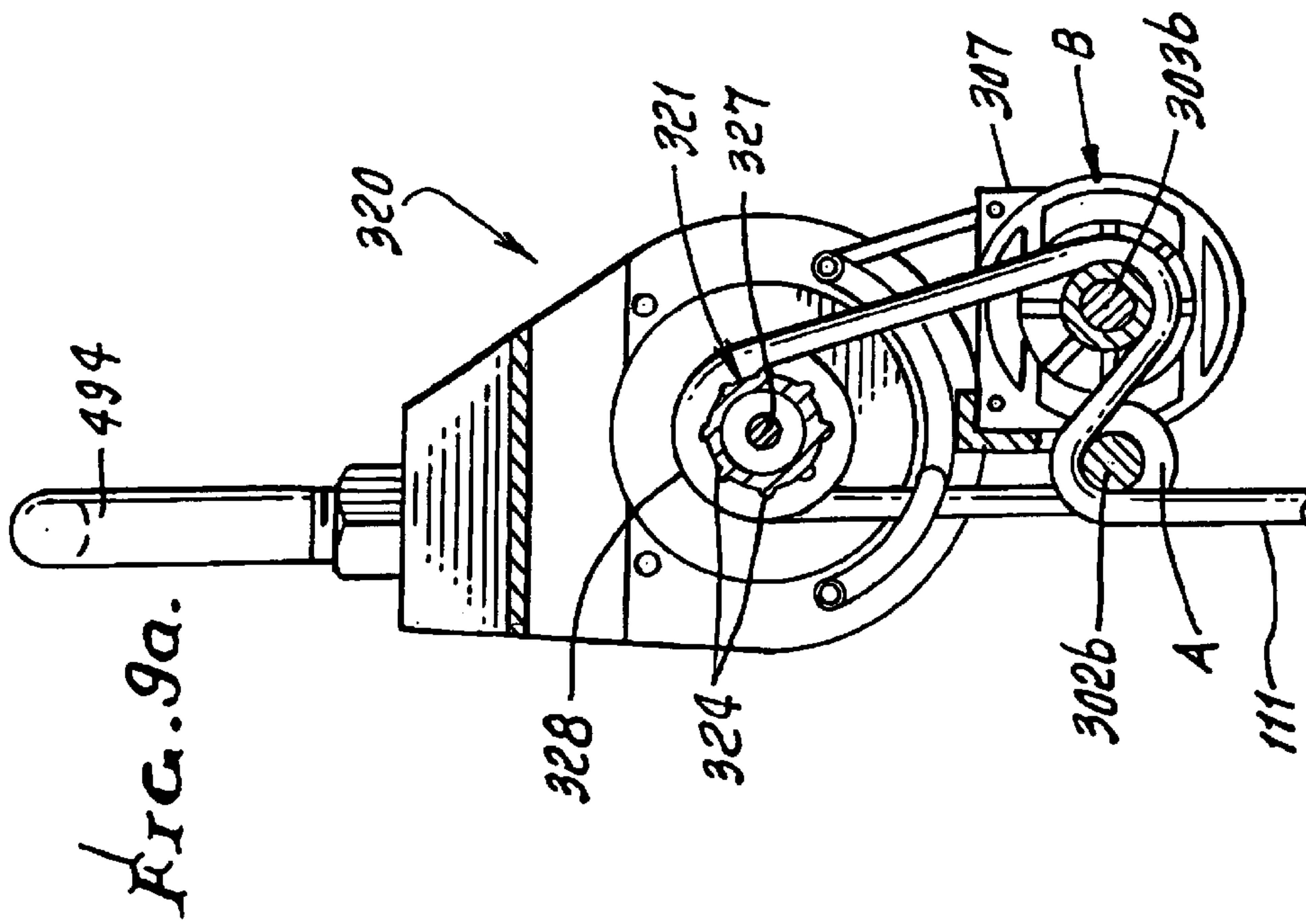
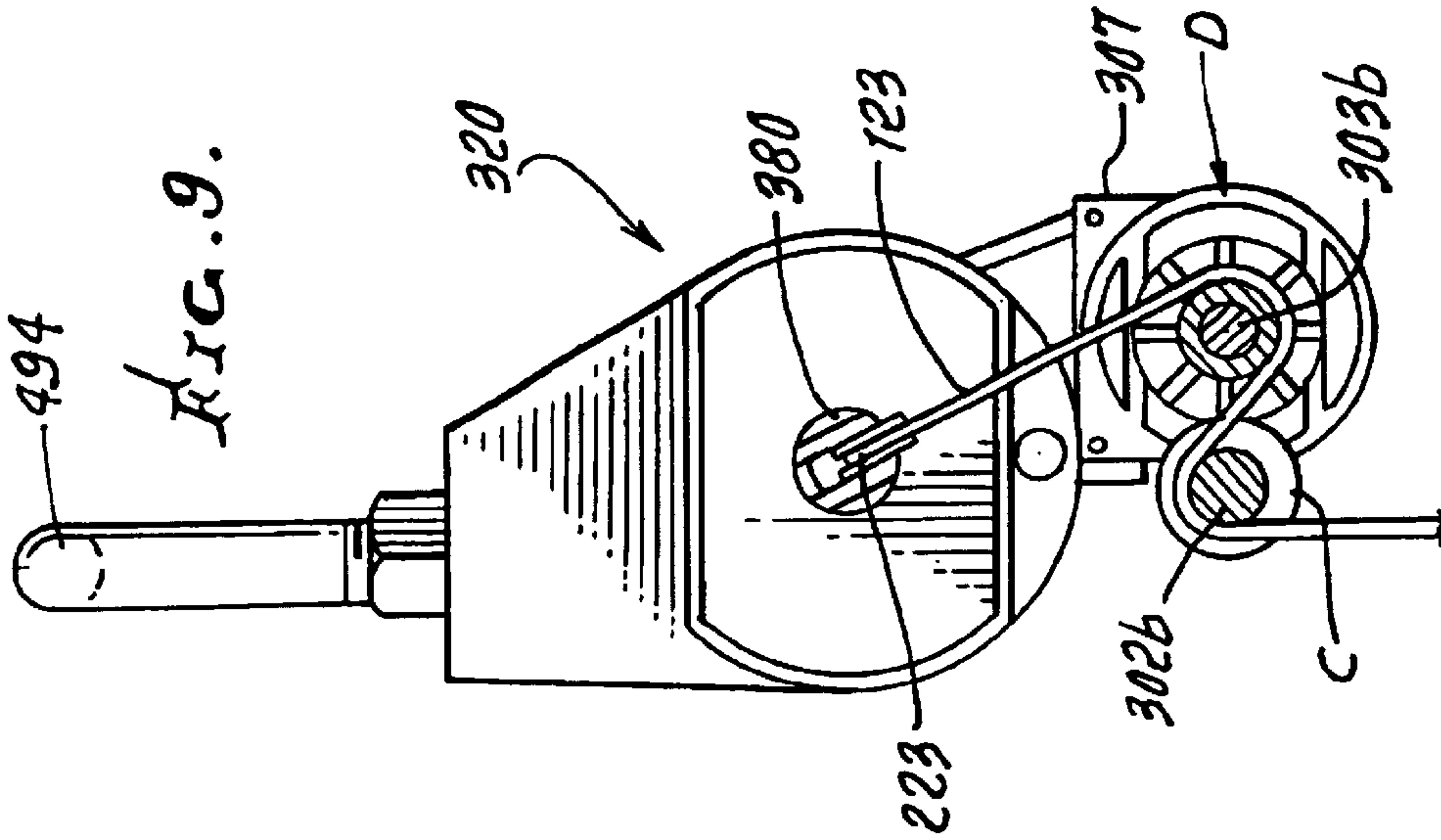


FIG. 10.

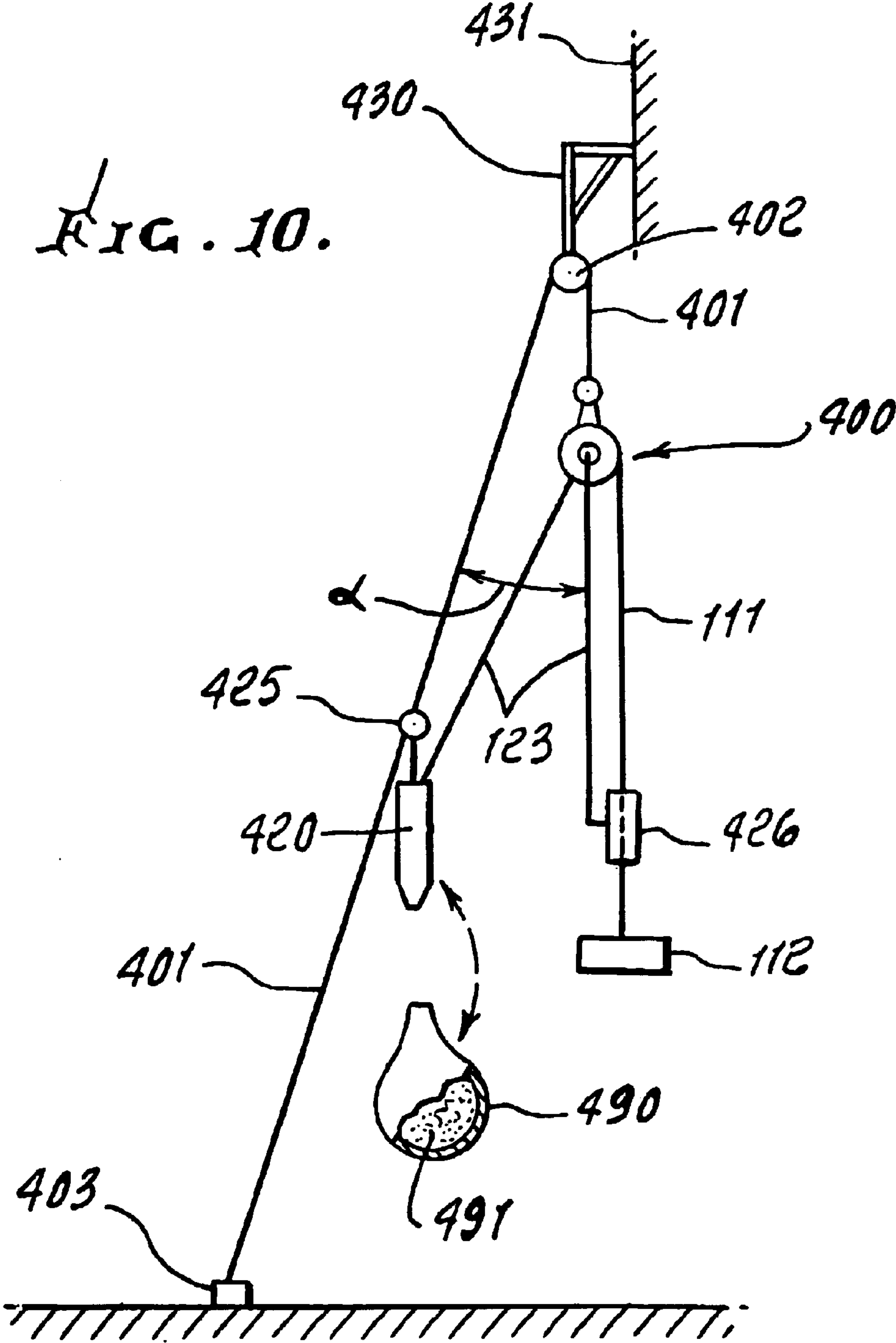


FIG. 11.

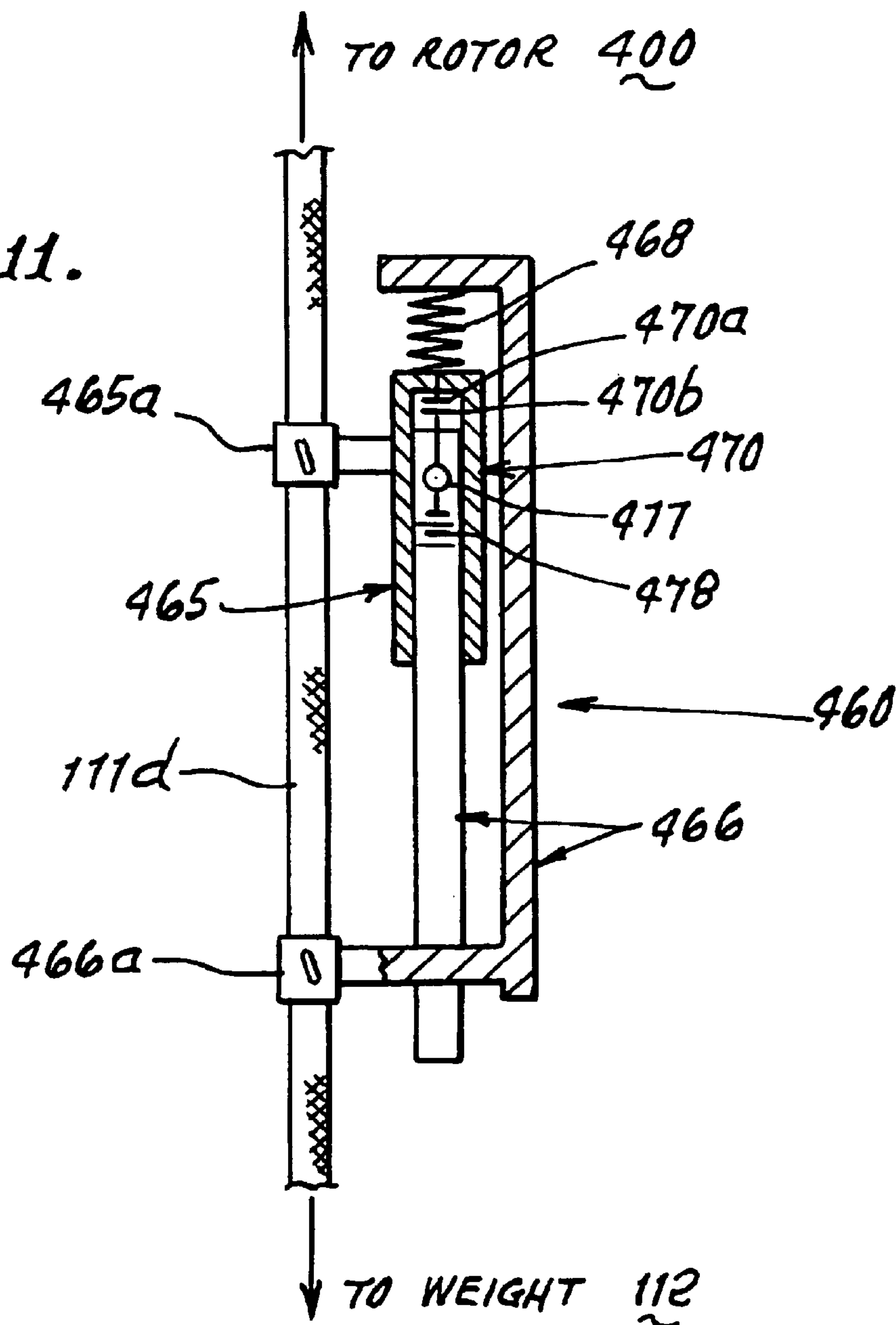


FIG. 12.

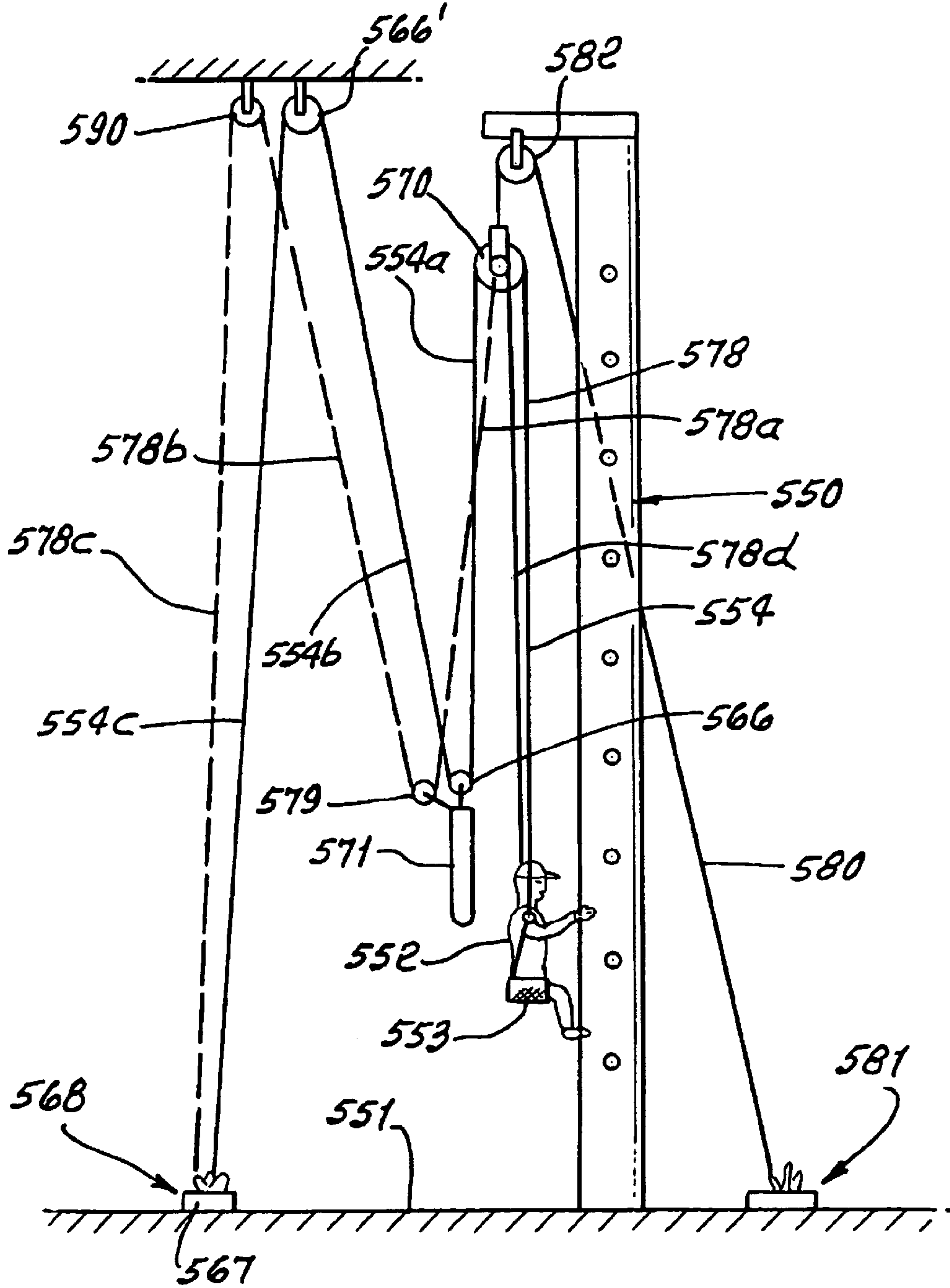
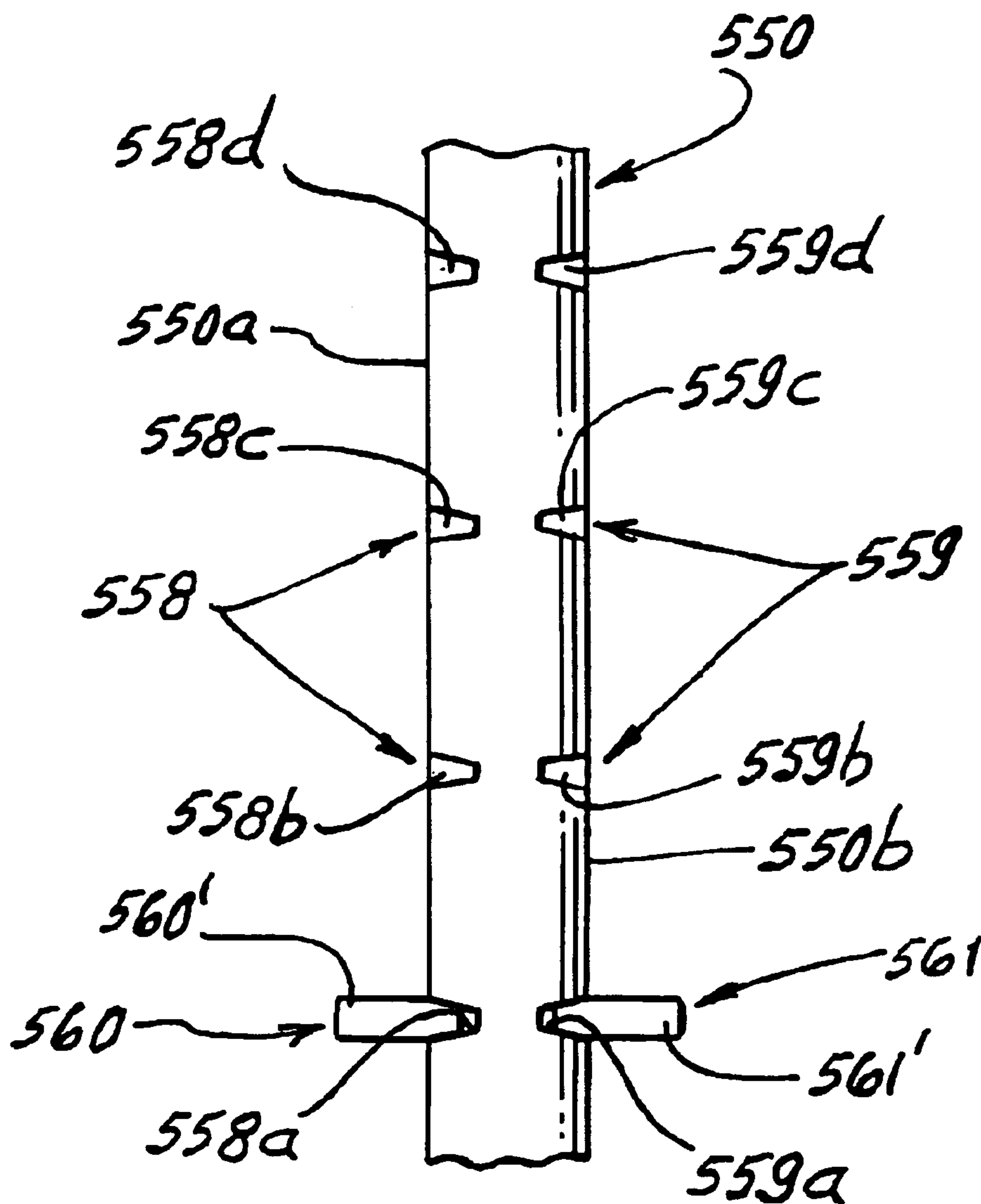


FIG. 13.



HIGH EFFICIENCY BELAY APPARATUS

This application is a continuation-in-part of U.S. patent application Ser. No. 09/580,123, filed May 30, 2000 abandoned, which is a continuation-in-part of Ser. No. 09/561,311, filed Apr. 28, 2000, now U.S. Pat. No. 6,186,276, which is a continuation of Ser. No. 09/126,652, filed Jul. 31, 1998, abandoned.

BACKGROUND OF THE INVENTION

This invention relates generally to automatic belay apparatus and its use; and more particularly it concerns the provision of safe, easily used, simple and compact, fall protection/lowering apparatus which can be employed in many situations to save lives and also for recreational purposes.

There is a known phenomenon that when a rope is wrapped around a fixed cylinder an X tension is applied to one end of the rope, a reactive force less than X (we will call Y) will stop the rope from slipping. More wraps around the cylinder will reduce the required Y force necessary for equilibrium.

Once equilibrium is attained between X and Y, reducing Y force by some Δ amount will allow the rope to slip. The amount of reduction in Y is dependent upon, among other things, the elasticity of the rope, the number of wraps around the cylinder, the diameter of the cylinder, and the co-efficient of friction between the rope and the cylinder.

To belay in nautical terms, is to "make fast (a rope) by winding on a cleat or pin".

If one is climbing, to be belayed is to be protected (by a rope) from falling. This is accomplished by wrapping a rope around the belayer, or some other object, so as to reduce the Y tension when a climber falls, creating X tension. The governing equation depicting this phenomenon is:

X tension	=	θ^a F Y tension
Where θ^a	=	Number of degrees, in radians, that the rope is in contact with a fixed cylinder
F	=	Coefficient of friction between the rope and the cylinder
a	=	Rope coefficient

Therefore, the greater number of wraps (radians), the lower Y is required for equilibrium.

And here is the paradox. If one wished Y to be minimal, multiple wraps are required; but, if one wishes to take up slack on the X rope when climbing by taking up Y tension, the weight of the rope X will be multiplied by the same factor (but in reverse) as when the climber falls which might make it impossible to take up slack, and hence a non-functional device.

As one example:

For a wire rope, with $5\frac{1}{2}$ wraps around a 3" pipe (3.5 O.D.),

$$X=50\# \text{ and } Y=0.12\#$$

Therefore, the amplification factor is

$$\frac{50\#}{.12\#} = 400$$

Now, remove the 49# weight leaving a 1# rope and try to pull Y. $Y=1\# \times 400=400\#$ to take up slack. This is not possible, or practicable.

Accordingly, there is need for improved apparatus to overcome the above problem so that slack can be automatically taken up while using the multiplying effect of multiple wraps; and there is need for apparatus which can be easily used for safe lowering of weights, as from great heights.

SUMMARY OF THE INVENTION

It is a major object of this invention to provide improved fall protection/lowering apparatus and methods, meeting the above needs. Basically, the apparatus of the invention is used for controlling vertical movement of a first weight (as for example a human being or other load), and comprises:

- a) a first element rotatable in one direction about an axis and a structure blocking said first element against rotation in the opposite rotary direction,
- b) a second element acting as a guide,
- c) a control weight,
- d) and lines supporting said first weight and control weight by said elements, and including a first line wrapping about the first element and a second line entraining the second element, whereby changes in force exertion on the control weight determine alternative existence of a first mode of operation wherein line slippage relative to the first element allows the first weight to descend, and a second mode of operation wherein line non-slippage relative to the first element thereby blocks descending of the first weight,
- e) and wherein
 - i) the first line that wraps about the first element has line portions that extend downwardly to support loading imposed by the first weight and control weight, respectively,
 - ii) the second line that entrains the second element has one line portion that extends downwardly to support control loading imposed proximate but independently of the first weight, and the one line portion not connected to the first weight, and another line portion to support loading imposed by the control weight.

Typically, the first line that wraps about the first rotor has line portions that extend downwardly to support loading imposed by the first weight and control weight, respectively; and the second line that entrains the second element also has line portions that extend downwardly to support loading imposed by the first weight and control weight respectively.

Another object is to provide a first rotor element with an extended surface to engage multiple, non-interfering wraps of the first line.

A further object is to provide the first rotor with two axially spaced generally conical portions, and a generally cylindrical portion intermediate those conical portions. Typically, the conical portions may have wrap engaging angularities characterized as maintaining the first line wraps free of sidewise interengagement or interference during operation of the apparatus to lower the first weight.

Accordingly, optimum operability and functioning of the first line and first rotor are maintained.

Yet another object is to provide the first rotor element with an axial through passage, the second line passing through that passage, whereby a high degree of compactness of the equipment is achieved.

An additional object is to provide support structure for a human being who imposes the first weight in order to be lowered, such support structure defined by an upright strut connected to the line wrapped about the first rotor, and a seating ledge connected to the strut. That ledge may advan-

tageously include at least one folding section having an up-folded position extending generally parallel to the upright stem, and a down-folded position extending generally laterally to seat the human being.

In use, the first rotor, i.e. a cylinder for example, is allowed to rotate freely in one direction (while taking up slack), and prevented from rotating in the opposite direction while resisting a fall. The taking up of slack is accomplished by hanging a weight on the Y reactive side of the cylinder greater than the weight of the rope on the X tension side of the cylinder; hence, in the above one example, Y need only be 1# to take up slack but it is strong enough to resist a 400# load during a fall.

If the device is to be used by a climber, once the climber has climbed he must be able to lower himself. This can be accomplished by attaching a separate control rope to the Y reactive weight, running this control rope through the first rotor element, or over a freely rotating sheave, and then attaching the control rope to the X load. By shortening the control rope, the Y reactive force will be reduced until slippage occurs. Since X and Y will remain the same distance apart during slippage, slippage will continue unabated until the control rope is allowed to lengthen, for example lifted.

It is another object of the invention to provide a governor that engages a line to slow the rate of descent of the first weight as that rate of descent increases. As will be seen, one advantageous and simple governor includes at least two sheaves about which the line is entrained, together with relatively rotatable discs in a fluid medium, certain discs driven by the rotor to produce fluid shear acting increasingly to slow rotation of the rotor in response to increasing rates of rotation of the rotor and said certain discs. Accordingly the rate of descent of the weight can be slowed by controlling the rate of ascent of the control weight, as that rate tends to increase.

Yet another object of the invention is to provide a hoist to hoist weight of a line that extends between a control weight and the first rotor, thereby to eliminate or substantially reduce the effect of decreasing line weight on control of the system, as the control weight ascends (which makes the first weight fall faster). In this regard, the hoist may advantageously be very simply and effectively integrated with the governor; for example, a line may be entrained by two governor sheaves A and B; and a control line may be entrained by two hoist sheaves C and D; a primary axle may carry the A and C sheaves to rotate together; and a secondary axle may carry the B and D sheaves to rotate together.

A further object includes provision of a guide line having an upper portion that suspends the rotor about which the defined first line is wrapped, and at an upper location, the guide line also having a lower portion that is anchored at a fixed lower location. That lower portion can be released to permit bodily lowering of the rotor, as will be seen, whereby a climber or person whose weight is suspended by the rotor, can be safely lowered in an emergency. In this regard, the path of descent or ascent of the control weight can be guided by the guide line, angled so as not to interfere with the paths of ascent or descent of the person whose weight is suspended by the rotor.

An additional object includes provision of a slack detector engaging a portion of the line, below the level of the rotor; together with a signal generator to generate a detectable signal upon occurrence of slack in said engaged portion of the line. The slack detector may advantageously have first and second parts that are relatively movable in the direction of the line, the parts having associated grips to grip the line

at locations spaced apart therealong, the signal generator (electrical or mechanical or other) being responsive to relative movement of such parts.

A further object includes provision of fin structure on the first rotor to act as a heat radiator during rapid slippage of the line in frictional wrapping or unwrapping engagement with the rotor, acting to generate heat.

Another object is to provide circularly spaced, axially extending protrusions on the first rotor, to be frictionally engaged by the first line wraps, to establish better control of wrap engagement with the rotor.

A yet further object is to provide apparatus for use in climbing of a pole, by a climber, and which includes

- a) a climber's harness for supporting the torso of a climber climbing the pole,
- b) first means for elevating that harness as the climber climbs the pole, and for blocking lowering of the harness,
- c) and second means carried by the pole for enabling climbing pull-up relative to the pole.

As will be seen, the second means may include a series of holes in the pole and spaced apart lengthwise of the pole to receive insertion of manually graspable pegs successively inserted into vertically successive holes. Typically, two of such pegs may be located respectively at opposite sides of the pole.

The first means referred to may include

- a) a first element including a rotor rotatable in one direction about an axis and blocked against rotation in the opposite rotary direction,
- b) a second element acting as a guide,
- c) a control weight,
- d) lines for supporting the climber's weight and the control weight by said elements, and including a first line wrapping about the rotor and a second line entraining the second element, whereby changes in force exertion on the control weight determine alternative existence of a first mode of operation wherein line slippage relative to the rotor allows the first weight (climber's weight) to descend, and a second mode of operation wherein line non-slippage relative to the rotor thereby blocks descending of the first weight.

Control means may be provided for supporting the rotor to be lowered relative to the pole, for safety purposes; and such control means may include a control line extending to a control location, to be extended for lowering the rotor relative to the pole.

These and other objects and advantages of the invention, as well as the details of an illustrative embodiment, will be more fully understood from the following specification and drawings, in which:

DRAWING DESCRIPTION

FIG. 1 is a perspective view of apparatus incorporating the invention;

FIG. 2 is an elevation showing modified apparatus incorporating the invention;

FIG. 3 shows a folding seat type support for a human who may wish to climb onto the seat as from a building window, and lower himself, safely, from a height, at the outer side of a building, using the apparatus as described;

FIG. 4 is a view like FIG. 2, but showing further modified apparatus, which is preferred;

FIG. 5 is a perspective view showing a rate-of-descent governor, in schematic form;

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FIG. 6 is an axial section taken through a torque exerting brake employing rotary elements in a fluid;

FIG. 7 is a schematic perspective view of a rate-of-descent governor integrated with a hoist mechanism;

FIG. 7a is an elevation showing a governor of the type shown in FIG. 7;

FIG. 8 is an axial section taken through a governor as seen in FIG. 7a, and also through a rotor element entraining first line wraps, there being wraps shown as engaging protrusions on the rotor;

FIG. 9 is a section taken on lines 9—9 of FIG. 8;

FIG. 9a is a section taken on lines 9a—9a of FIG. 8;

FIG. 10 is a diagrammatic view showing the rotor element suspended by a hoisting line or rope, and enabling lowering of the rotor element and suspended climber;

FIG. 11 is a view showing a line slack detector connectible to a selected line;

FIG. 12 is an elevation showing a climbing pole and associated climbing apparatus; and

FIG. 13 is an enlarged section showing climbing pegs inserted in, and successively insertible in, vertically spaced holes in the climbing pole.

DETAILED DESCRIPTION

In FIG. 1, a first load bearing rotor 10 such as a cylinder, is rotatable in one direction (clockwise, for example) but is blocked against rotation in the opposite rotary direction (counter-clockwise, as shown). Suitable bearing supports are shown at 11 and 12, to support the axle 13 supporting the rotor, and extending in the axial direction indicated at 14. A device to block counter-clockwise rotation may take the form of a ratchet arm 15 engaging ratchet teeth on the rotor. A suitable frame 19 supports 11, 12 and 15. Frame 19 may for example be attached to the outer side of a building.

A second rotor 16, such as a sheave or pulley, is supported to be freely rotatable in opposite directions about an axis. In the example, the rotor 16 may be carried by axle 13 to be freely rotatable about axis 14.

Two weights are supported by the two rotors. These include a first weight 20 and a control or reaction weight 21, the weights in this example hanging from the rotors, as via supporting lines. These include a first line 22 supporting first weight 20 and wrapping about the rotor at wrap locations 22a at which each turn of the wrap engages the rotor surface, line 22 then extending downwardly at 22b to assist in supporting the control weight 21. The lines also include a second line 23 extending downwardly toward the first weight 20, and also extraining the sheave at location 23a; line 23 then extends downwardly at 23b to assist in supporting the control weight 21.

Changes in force exertion determine alternative existence of a first mode of operation wherein line slippage relative to the first rotor allows the first weight to descend, and a second mode of operation wherein line non-slippage relative to the first rotor thereby blocks descending of the first weight.

By "shortening" the line 23 (for example by manually lifting line 23b) reactive force is reduced, until slippage of line 22 occurs at the wrap locations 22a, and slippage will continue, accompanied by lowering of first weight 20, until line 23b is allowed to "lengthen", i.e. eliminating or reducing manual lifting of line 23. Note that lines 22 and 23, near the weight 20, travel downwardly together during such slippage. Slippage at the wrap locations is prevented by friction, when the line 23 is "lengthened".

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Table A below indicates that, depending upon the type of line (such as rope) and, the amount of weight "removed" as by lifting line 23b to allow slippage is affected by the number of wraps. (These results are results obtained for a selected set of rotors.)

TABLE A

Auto-Belayer Test					
Wraps	Material	X	Y	T	
3.5" Steel Shaft					
3.32" Wire Rope (1000 lb. cap.) weighing 0.015 lbs per foot.					
1.4" Twisted Sisal Rope (45 lb. Working load Limit) weighing 0.015 lbs. per foot.					
1.4" Twisted Nylon Rope (124 lb. Working Load Limit) weighing 0.012 lbs. per foot.					
X = 50 lb. load.					
Y = Weight to just Balance Load.					
A = Amount of Weight removed from Y to allow slippage.					
Wraps = Number of times the Material is around the Steel Shaft.					
T = Time to fall 20" when Y made 0.0 lbs.					
Wraps = 5 1/2					
	Wire Rope	50	.12	.12	1.31 sec.
	Sisal	50	.36	.24	4.37 sec.
	Nylon	50	.98	.48	9.50 sec.
Wraps = 4 1/2					
	Wire Rope	50	.96	.48	.90 sec.
	Sisal	50	.96	.24	3.00 sec.
	Nylon	50	1.20	.24	1.38 sec
Wraps = 3 1/2					
	Wire Rope	50	1.44	.48	.40 sec.
	Sisal	50	2.28	.84	1.55 sec.
	Nylon	50	3.41	.48	.38 sec.
Wraps = 2 1/2					
	Wire Rope	50	4.18	1.5	Fast
	Sisal	50	6.0	2.3	Fast
	Nylon	50	7.11	.50	Fast
Wraps = 1 1/2					
	Wire Rope	50	13.82	5.00	Fast
	Sisal	50	11.8	3.5	Fast
	Nylon	50	16.22	2.00	Fast
Wraps = 1/2					
	Wire Rope	50	33.13	7.00	Fast
	Sisal	50	22.09	3.5	Fast
	Nylon	50	33.51	3.00	Fast
Wraps = 5/8					
	Nylon	50	.48	.48	very slow movement
Wraps = 4/8					
	Nylon	50	1.20	.24	very slow movement
	Nylon	50	1.20	1.08	5 seconds per foot
	Nylon	50	1.20	1.20	1 second per foot

The following are four important features:

1. Increasing wraps around a cylinder will non-linearly increase the force amplification until it eventually reaches an asymptotic limit.
2. To take up slack, the cylinder must rotate in one direction while, acting as a force amplifier, it cannot be allowed to rotate in the opposite direction.
3. The type of rope combined with the number of wraps affects the lowering sensitivity.
4. A deadweight in series with the device on the Y reactive side can act to both protect the climber from a fall and control the rate of his descent.

Referring now to FIG. 2, showing modified and preferred apparatus 100, it includes a modified first rotor 110 about which a cable or line 111 is wrapped via multiple turns, at 111a. Line 111 extends downwardly to support a first weight 112 and may be operatively connected to the weight. The rotor 110 is shown as rotatable about a horizontal axis 113. The rotor has a through bore 110a through which a cylindrical duct 114 extends. The duct projects at opposite ends of the rotor and which may be supported by bearings 115 and

116 to allow free rotation of the rotor and duct about axis **113**. Those bearings are carried by fixed walls **115a** and **116a**.

The opposite end extent **111b** of line or cable **111** extends downwardly to a freely hanging control weight **120**. The line **111b** is shown as turned by pulleys or idlers **117** and **118**, as shown, whereby control weight **120** may be located remotely from the weight **112**. Fixed structure **117a** and **118a** supports the idlers.

A second rotor or rotors **121** is or are shown, as at the end or ends of the duct **114**. A second cable or line **123** entrains the rotor or rotors **121**. One end portion **123a** of line **123** extends to control weight **120**, and is turned via idlers **124** and **125** as shown. The opposite end portion **123b** of the line **123** extends downwardly toward weight **112**. Since the line **123** slidably extends through the interior **114b** of the duct **114**, and therefore through windings **111a**, a very compact and simple assembly is provided, with lines **111** and **123b** extending close to one another and almost directly downwardly toward the weight **112**; also line extents **123a** and **111b** may extend close together toward the remotely located control weight, and within a protective duct **140**, to shield lines **111** and **123b** from the weather.

Raising or lowering of the line extent **123b**, as via a control sleeve **126** extending about line **111** in proximity to weight **112**, controls the rate of descent of the weight **112**, as via control of control weight application to line extent **111b**. Such control variations control the friction forces exerted by the multiple wraps at **111a** on the surface of the rotor **110**, which in turn controls the slippage rate. A ratchet is indicated at **160**, for preventing reverse rotation of the rotor **110**.

For enhanced control of such slippage, the first rotor **110** may be provided with two axially spaced generally conical surface portions **110b** and **110c**, and a generally cylindrical surface portion **110d** intermediate the conical portions. The conical portions are interrupted by short cylindrical lands shown at **110e** and **110f**. It is found that such configurations serve to maintain the multiple wraps axially separated sufficiently as to avoid development of side-by-side rubbing of the multiple wraps. Such rubbing would otherwise interfere with accurate control of slippage of the wraps on the rotor. A means may be provided to urge line **111** leftwardly, to additionally assist in keeping the turns from side-by-side rubbing. Such means may comprise an idler **130** urged leftwardly as by a spring **131**. Raising of weight **112** is associated with take-up of slack in line **123b**, the importance of which is explained later, especially for safe climbing purposes.

A support may be provided for the weight **112** referred to, that support connected to at least one of the first and second lines. FIG. 3 shows the support in the form of a ledge **140** to seat a weight such as a human being. An upright strut **141** is connected to the ledge, and line **111** is shown connected to the strut. Ledge **140** is shown as including left and right sections **140a** and **140b** pivoted to the strut at **142**, as by hinges. Accordingly, the seating sections **140a** and **140b** may be swung down to the section position **140b** shown at such time as a human is to step onto the support to controllably and safely descend from a height, as at the outer side of a building, to escape from fire.

The rotors **121** may be non-rotary guides for line **123**; and the bore of tube **114** may also or alternatively act as a line guide.

In the preferred apparatus of FIG. 4, the elements that remain the same as those in FIG. 2 carry the same identifying numerals. The rotor **210** (like rotor **110**) has annular flanges **215** and **216** at its opposite ends, and which are

received in annular grooves **215a** and **216b** in the fixed walls **217** and **218** of the frame **219**. Those flanges or tongues rotate in the grooves about axis **113** as the rotor rotates, with loading transferred from rotor **210** to walls **217** and **218** via annular bearing surfaces provided at **215** and **215a**, and at **216** and **216a**. Surfaces **110b**, **110c**, **110d** and **110e** are the same as in FIG. 2, as are the line **111**, wrappings at **11a**, and line extent **111b**.

Duct **214** is non-rotatable, and has its opposite ends clamped, via nuts **221** and **222** to the fixed walls **217** and **218**. Those nuts have screw threaded attachment at **221a** and **222a** to the duct. Duct **214** serves as a guide or guide duct for the line section **223** passing through the duct, i.e. through windings **111a**. The opposite end interior surfaces **214a** and **214b** are flared or turned, as shown, to act as slide guides for the line **223**, to turn that line as shown, thereby eliminating need for the pulleys **121** as seen in FIG. 2. See also fixed, non rotary guides for the lines, at **224**, **227**, **228**, and **225**.

Protective duct **240** shields lines **123b** and **111b** from the weather. Pulleys **240** and **241** are carried by the control weight **220**, to turn lines **123a** and **111b**, as shown, the ends of those lines being attached to **240**. Therefore, weight **120** need only travel one half the vertical distance at it travels in FIG. 2, as weight **112** is lowered; and as it is raised. Raising of weight **112** is associated with lowering of control weight **120**, which serves to take up slack in control line portions **123**, **123a** and **123b**. This is important for example where the weight **112** is a human climber, climbing a wall or rock face, whereby he may use non-slack line **123b** to control or stop a fall, immediately.

Referring now to FIGS. 5 and 6, they schematically show provision of a control such as a governor **300**, on the control weight side of the rotor, for slowing the rate of ascent of the control weight **120**, as that rate increases, if and when such rate increase occurs. The governor is shown as engaging control line **111b** to slow its ascent with weight **120**.

A simple, effective governor includes at least two sheaves or pulleys **302** and **303**, about which the line **111b** is entrained, as at under and over sheave engagement zones **302a** and **303a**. The sheaves are carried by primary and secondary axles **302a** and **302b**, supported by structure **304** attached for example to the frame **305'** that carries rotor **110**. Suitable bearings may be provided as at **302c** and **303c**, whereby the sheaves are rotatable about parallel axes. The sheaves are otherwise indicated at A and B, as also represented in FIG. 7.

Rotation of one of the sheaves, as for example sheave B, is resisted, as by a restraint that increases as the line **111b** rate of ascent increases, thereby to slow or control that rate of descent, of the weight **112**, the objective being to prevent free-fall of the suspended weight or climber, in an emergency. As shown in FIG. 6, the resistance to rotation i.e. damping of sheave B and its axle **303b** is suitably provided as by fluid shear, acting for example upon a disc or discs **305** connected to axle **303b**. Discs **305** rotate closely adjacent and between fixed discs **306**, within a housing **307** containing fluid **307a** extending in the small gaps between discs **305** and **306**. The fluid shear, produced in response to such relative rotation, acts increasingly to slow rotation of the rotor **303** in response to increasing rates of rotation of the rotor **303** and the discs **305**.

Also shown in FIG. 7 is a reactive line hoist **310** operable to hoist weight of the reactive line **123a** in the region below the rotor **210** and extending downwardly to control weight **120**. The objective is to eliminate or reduce the effect of weight of the reactive line **111** upon the system. That effect would otherwise change as the control weight **120** moves

upwardly, and would tend to unbalance the system if it were not counteracted.

The hoist **310** is shown as operatively connected, or integrated, with the governor, to simplify the overall apparatus. In the example, the hoist includes two sheaves or pulleys **311** and **312** about which reactive line **123a** is entrained, as at under and over sheave engagement zones **311a** and **312a**. The hoist sheaves are shown as carried by the axles or shafts **302a** and **303a**, and are otherwise designated at C and D. Thus, primary axle **302b** carries sheaves A and C to rotate, and secondary axle **303b** carries the B and D sheaves to rotate. When control weight **120** is lifted by line **123a** sheaves A and B rotate which will in turn lift the segment line **111b** between the rotor and the control weight **120**; hence, negating the weight of this rope segment upon the operation of the device when lowering weight **112**. FIG. **7a** is a side elevation view of an apparatus as shown in FIG. **7**, and in greater detail. Note that B and D sheaves have greater diameters than A and C sheaves.

Referring now to FIGS. **8** and **9**, they show a modified first rotor **320** having a cylindrical middle section **321**, and opposite end sections **322** and **323** which have surfaces **322a** and **323a** which taper toward **321**. Sections **322** and **323** are typically conical and hollow. The angularities of the surfaces of **322** and **323** are such as to maintain the first line wraps or turns **328** free of such sidewise interference, as would prevent free wrapping and unwrapping, during operation. Fins or discs are provided at **322c** and **323c** on the rotatable rotor, for dissipating heat generated by line wrap frictional engagement with the rotor, during slippage of the line wraps on the rotor.

Shallow ribs are shown at **324** in FIGS. **8** and **9a** as protruding from only the conical surface **322a** to be engaged by the first line wraps; the ribs extend generally longitudinally in the general direction of the rotor axis **327**, and may have reduced height in a direction toward a mid-portion of the rotor. It is found that such ribs positively grip the line wraps **328**, and prevent unwanted slippage. They also enhance the control amplification factor. The ribs are spaced about axis **327**, as shown in FIG. **9**. A suspension ring is shown at **494**.

The rotor **320** has an axial through passage **330**, for passing line section **223**, as described above in connection with FIG. **4**. Line turning sheaves are seen at **330a** and **330b**, and carried by rotor frame structures **380** and **381**. A spring urged friction clutch **370** in FIG. **8** rotatably connects sheave D to shaft **330b**, whereby the hoisting action can de-couple from shaft **303b**, enabling control line **123** to be operated independently of hoisting action, below a selected level of hoisted weight.

Turning now to FIG. **10**, it shows a rotor **400** suspended as by a guide or hoisting line **401** having an upper portion that extends upwardly over a pulley **402**, and then downwardly at an angle α relative to vertical. Rotor **400** may correspond to any of the line wrapping rotors discussed above. A lower anchor at **403** releasably anchors the lower portion of line **401**. Line **111** suspends the weight or climber **112**, and wraps about the rotor **400**. Control line **123** extends through the axial passage in the rotor, and then to control weight **420**. The opposite end or tail end of line **123** extends downwardly to attach to the sleeve or control grip **426** through which line **111** extends. Line **111** also extends to the control weight, as in FIG. **4**. The control weight **420** is guided by hoisting or suspending line **401** for up and down movement, lengthwise along line **401**, i.e. away from the vertical up-down path of movement of the suspended weight or climber **112**, so as not to interfere with movement of the

latter. A ring **425** on the control weight **420** is shown as passing the hoisting line. In an emergency, the anchor at **403** can be released by another person to lower the suspended climber or weight **112**.

The pulley **402** may be suspended at **430** as from a geologic formation face indicated at **431**; or from a building proximate the exterior side of the building, also represented by **431**. As stated, rotor **400** may take the form of any of the previously described rotors that suspend the weight or climber.

FIG. **11** shows a slack detector **460** for engaging a portion **111d** of the first line between the rotor **400** and the suspended weight or climber **112**, for detecting the occurrence of slack in that line, should it develop. The detector includes first and second parts **465** and **466** that are relatively movable in the direction of the first line. Those parts have associated grips, seen at **465a** and **466a**, to compressively grip the first line at spaced locations along its length. A compression spring **468** is located to urge the two parts in relative directions tending to urge the grips toward one another. If slack develops in the line **111**, the grips gripping the line will then move relatively toward one another, and a signal generator responds to generate a detectable signal, such as an audible sound which the climber can hear, and/or which the person controlling the hoist or guide line **401** can also hear. That line can then be manipulated to lower the climber to safety. One signal generator is shown at **470** and comprises electrical contacts **470a** and **470b** movable together in response to relative movement of the two parts and grips. A switch is thereby closed to operate the sounder **477** in series with the contacts and a battery **478**.

In FIG. **10**, the control weight **420** can take the form of an alternative weight comprising a lightweight container **490** (such as a bag or sack) adapted to receive loose particles **491** such as sand, dirt, or gravel, at a climbing site. This avoids need to transport a solid control weight to the site.

The ratchet **160** may take the form of arcuate ramps terminating at blocking shoulders, on the end face of flange **320a**, in FIG. **8**

Referring now to FIGS. **12** and **13**, a climbing pole is shown at **550** extending upwardly from the ground or support zone **551**. A climber **552** is carried or attached to a harness **553** from which a line extends upwardly at **554** for supporting the climber, i.e. his torso or body, in association with his climbing the pole.

First means is provided for elevating the harness as the climber climbs the pole, and may be considered to include line **554**. That first means is further characterized as blocking lowering of the harness, relative to the pole, during the climb. Second means is provided to be carried by the pole for enabling climbing pull-up by the climber, relative to the pole, as during the climb.

As shown in FIG. **13**, that second means may preferably take the form of a series of holes in the pole and spaced apart lengthwise of the pole to receive insertion of manually graspable pegs successively inserted into vertically successive holes. See for example the vertically spaced holes **558** at one side **550a** of the pole, and vertically spaced holes **559** at the opposite side **550b** of the pole, the holes extending laterally into the pole as shown, preferably with taper. Typically, there are two of the pegs **560** and **561** located at said opposite sides of the pole, to project into the holes. The climber supported by his harness removes those pegs from lower holes **558a** and **559a** at one level and inserts them into the next above level holes **558b** and **559b**; he then pulls himself up by grasping the projecting extents **560'** and **561'** of the pegs and exerting lifting force to raise his body to a

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level enabling hand removal of the pegs from holes **558b** and **559b** and insertion of the removed pegs into the next above level holes **558c** and **559c**. This process of intermittent body lifting, and peg removal and insertion into successively next above holes, is repeated over and over to achieve the climb. 5
During this process, the harness and its indicated elevating support means enables automatic harness elevation with the climbers torso or body (a control weight **571** then lowering); and also blocks lowering of the harness, for example until such lowering of the harness and climber is desired. 10

The structure associated with the harness for achieving such controlled harness movement preferably includes the following, considering that the climber's weight and associated weight of the harness is a "first weight":

- a) a first element including a rotor rotatable in one direction about an axis and blocked against rotation in the opposite rotary direction, 15
- b) a second element acting as a guide,
- c) a control weight, 20
- d) lines supporting said first weight and control weight by said elements, and including a first line wrapping about the rotor and a second line entraining the second element, whereby changes in force exertion on the control weight determine alternative existence of a first mode of operation wherein line slippage relative to the rotor allows the first weight to descend, and a second mode of operation wherein line non-slippage relative to the rotor thereby blocks descending of the first weight. 25

Referring to the FIG. **12** example, the first element including the rotor is indicated at **570** the rotor for example taking the form of rotor **210** in FIG. **4**; the second element acting as a guide may take the form of guide seen at **214** in FIG. **4**. The control weight **571** corresponds to weight **120** in FIG. **4**. The lines supporting the first weight (the weight of the climber **552**) and the control weight **571** are indicated at **554**, **554a**, **554b**, and **554c**. First line **554** supports the first weight (the climber's weight) and wraps about the rotor to extend downwardly at **554a** to a pulley **566** suspending control weight **571**. Line **554a** then extends upwardly at **554b** and over a fixed position pulley **566'** to then extend downwardly at **554c** and terminate at a fixed support **567** at control station **568**. A second line **578** entrains the guide at the rotor (for example passes through tubular part **214** seen in FIG. **4**); line extension **578a** then extends downwardly to pulley **579** on weight **571**, then upwardly at **578b** to fixed position pulley **590**, and then downwardly at **578c** and to the control station **568**; and line extension **578d** extends downwardly near the pole **550**, to be manipulated by the climber. 30

This system blocks unwanted lowering of the climber, as during his climbing ascent, but enables controlled lowering of the climber, by his manipulation of line extension, hanging near the pole. 35

Also provided is a means for suspending and lowering the rotor **570**, as during an emergency. See control line **580** extending downwardly to a control station **581**, and extending upwardly over a fixed pulley **582** to support and suspend the rotor, as via rotor frame seen at **218** in FIG. **4**. Control line **580** may be untied and payed out at station **581** to lower the rotor **570**, and the suspended climber, as during such emergency. 40

I claim:

1. Apparatus used in controlling vertical downward movement of a first weight, comprising:

- a) a first element rotatable in one direction about an axis and a structure blocking said first element against rotation in the opposite rotary direction, 45

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- b) a second element acting as a guide,
- c) a control weight,
- d) and lines supporting said first weight and control weight by said elements, and including a first line wrapping about the first element and a second line entraining the second element, whereby changes in force exertion on the control weight determine alternative existence of a first mode of operation wherein line slippage relative to the first element allows the first weight to descend, and a second mode of operation wherein line non-slippage relative to the first element thereby blocks descending of the first weight,
- e) and wherein
 - i) the first line that wraps about the first element has line portions that extend downwardly to support loading imposed by the first weight
 - ii) and control weight, respectively,
 - iii) the second line that entrains the second element has one line portion that extends downwardly to support control loading imposed proximate but independently of the first weight, and the one line portion not connected to the first weight, but extending near to the first line, and another line portion to support loading imposed by the control weight. 50

2. The apparatus of claim **1** including a support for the weight, and connected to at least one of the first and second lines.

3. The apparatus of claim **2** wherein said support has structure to support a human imposing said first weight.

4. The apparatus of claim **1** wherein said elements are rotors that have a common axis.

5. The apparatus of claim **1** in which the first element is a first rotor having an extended surface to engage multiple wraps of the first line, and the second element is associated with the first element. 55

6. The apparatus of claim **5** wherein the first rotor extended surface has two axially spaced generally conical portions, and a generally cylindrical portion intermediate said conical portions.

7. The apparatus of claim **6** wherein said conical portions have wrap engaging angularities characterized as maintaining the first line wraps free of sidewise interference during operation of said apparatus to lower said first weight.

8. The apparatus of claim **3** wherein said first weight support structure defines an upright medial strut and a ledge to seat a human being.

9. The apparatus of claim **8** wherein said ledge includes at least one folding section having an up-folded portion extending generally parallel to said upright stem, and a down-folded position extending generally laterally to seat the human being. 60

10. The apparatus of claim **1** including a support frame, the first element carried by said frame to rotate relative thereto, the second element associated with the frame.

11. The apparatus of claim **10** wherein the first element is a rotor, said rotor and the frame defining a tongue and groove annular bearing or bearings whereby the frame directly supports the rotor for rotation.

12. In combination with the apparatus of claim **1**, said first element being a rotor having an extended surface, and rotatable about a first axis extending longitudinally, and including ribs protruding from said extended surface to be engaged by a first line, said ribs extending generally longitudinally and having progressively reduced height in a direction toward a mid-portion of said rotor.

13. The combination of claim **12** wherein said ribs are spaced apart about said axis.

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14. The combination of claim 12, wherein said rotor extended surface has two axially spaced generally conical portions, and a generally cylindrical portion intermediate said conical portions.

15. The combination of claim 12 wherein said rotor has an axial through passage, and said second line passes through said passage.

16. Climbing apparatus in combination with the apparatus of claim 1, and which comprises, in further combination:

- a) an upright climbing pole, in association with the line supporting the first weight,
- b) a climbing harness for supporting the torso of a climber climbing the pole,
- c) first means for elevating said harness as the climber climbs the pole, and for blocking lowering of the harness,
- d) and second means carried by the pole for enabling climbing pull-up relative to the pole.

17. The combination of claim 16 wherein said second means includes a series of holes in the pole and spaced apart lengthwise of the pole to receive insertion of manually graspable pegs successively inserted into vertically successive holes.

18. The combination of claim 17 wherein there are two of said pegs at opposite sides of the pole.

19. The combination of claim 16 wherein said first means includes a rotor, a line connected to said harness and to a control weight, said line entraining said rotor.

20. Apparatus used for controlling vertical downward movement of a first weight, comprising:

- a) a first element rotatable in one direction about an axis and blocked against rotation in the opposite rotary direction,
- b) a second element acting as a guide,
- c) a control weight,
- d) and lines supporting said first weight and control weight by said elements, and including a first line wrapping about the first element and a second line entraining the second element, whereby changes in force exertion on the control weight determine alternative existence of a first mode of operation wherein line slippage relative to the first element allows the first weight to descend, and a second mode of operation wherein line non-slippage relative to the first element thereby blocks descending of the first weight,
- e) said first element being a first rotor having an extended surface to engage multiple wraps of the first line, and the second element associated with the first element,
- f) said rotor extended surface having two axially spaced generally conical portions, and a generally cylindrical portion intermediate said conical portions,
- g) and wherein said first rotor has an axial through passage, and said second line passes through said passage.

21. Apparatus used in controlling vertical movement of a first weight, comprising:

- a) a first rotor rotatable in one direction about an axis and blocked against rotation in the opposite rotary direction,
- b) a guide,
- c) a control weight,
- d) and lines supporting said first weight and control weight by said rotor and guide, and including a first line wrapping about the first rotor and a second line entrain-

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ing the guide, whereby changes in force exertion on the control weight determine alternative existence of a first mode of operation wherein first line slippage relative to the first rotor allows the first weight to descend, and a second mode of operation wherein first line non-slippage relative to the first rotor thereby blocks descending of the first weight, the control weight acting to remove slack in the second line as the first weight rises, said guide defined by the rotor to have second line entrainment passage surface extent.

22. The apparatus of claim 21 wherein said guide comprises one of the following:

- x₁ a sheave,
- x₂ a passage through the first rotor.

23. The apparatus of claim 21 including a protector extending about at least one of said lines extending upwardly from said control weight.

24. The apparatus of claim 21 including pulley means carried by the control weight and entraining said lines whereby travel of the control weight is reduced relative to travel of the first weight.

25. The combination of claim 21 including a protective duct extending about said control weight and the lines proximate the control weight.

26. Apparatus used for controlling vertical downward movement of a first weight, comprising:

- a) a first element rotatable in one direction about an axis and blocked against rotation in the opposite rotary direction,
- b) a second element acting as a guide,
- c) control weight,
- d) and lines supporting said first weight and control weight by said elements, and including a first line wrapping about the first element and a second line entraining the second element, whereby changes in force exertion on the control weight determine alternative existence of a first mode of operation wherein line slippage relative to the first element allows the first weight to descend, and a second mode of operation wherein line non-slippage relative to the first element thereby blocks descending of the first weight,
- e) said first element being a first rotor having an extended surface to engage multiple wraps of the first line, and the second element being associated with the first element,
- f) and said first rotor having an axial through passage, and said second line passing through said passage.

27. Apparatus for use in controlling vertical downward movement of a first weight, comprising:

- a) a first element rotatable in one direction about an axis and a ratchet blocking rotation in the opposite rotary direction,
- b) a second element acting as a guide,
- c) a control weight,
- d) and lines supporting said first weight and control weight by said elements, and including a first line wrapping about the first element and a second line entraining the second element, whereby changes in force exertion on the control weight determine alternative existence of a first mode of operation wherein line slippage relative to the first element allows the first weight to descend, and a second mode of operation wherein line non-slippage relative to the first element thereby blocks descending of the first weight, the first element being a first rotor having an axial through

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passage, and said second line passes through said passage, the first rotor having two axially spaced generally conical portions, and a generally cylindrical portion therebetween.

28. The apparatus of claim 27 including said support for the first weight, and connected to at least one of the first and second lines.

29. The apparatus of claim 28 wherein said first weight support has structure to support a human imposing said first weight.

30. The apparatus of claim 27 wherein said elements have rotor surfaces that have a common axis.

31. The apparatus of claim 27 wherein:

i) the first line that wraps about the first element has line portions that extend downwardly to support loading imposed by the first weight and control weight, respectively,

ii) the second line that entrains the second element also has line portions that extend downwardly to support loading imposed by the first weight and control weight respectively.

32. The apparatus of claim 27 in which the first element is the first rotor having an extended surface to engage multiple wraps of the first line, and the second element is associated with the first element.

33. The apparatus of claim 32 wherein said conical portions have wrap engaging angularities characterized as maintaining the first line wraps free of sidewise interference during operation of said apparatus to lower said first weight.

34. The apparatus of claim 29 wherein said first weight support structure defines an upright medial strut and a ledge to seat a human being.

35. The apparatus of claim 34 wherein said ledge includes at least one folding section having an up-folded portion extending generally parallel to said upright stem, and a down-folded position extending generally laterally to seat the human being.

36. The apparatus of claim 27, including a support frame, the first element carried by said frame to rotate relative thereto, the second element associated with the frame.

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37. The apparatus of claim 36 wherein the first element is a rotor, said rotor and the frame defining a tongue and groove annular bearing or bearings whereby the frame directly supports the rotor for rotation.

38. The apparatus of claim 27 wherein the force exertion on the control weight is by one of the following:

i) a person being allowed to descend,

ii) a person at a control location, and not being allowed to descend.

39. Apparatus for use in controlling vertical downward movement of a first weight, comprising:

a) a first element rotatable in one direction about an axis and a ratchet blocking rotation in the opposite rotary direction,

b) a second element acting as a guide,

c) a control weight,

d) and lines supporting said first weight and control weight by said elements, and including a first line wrapping about the first element and a second line entraining the second element, whereby changes in force exertion on the control weight determine alternative existence of a first mode of operation wherein line slippage relative to the first element allows the first weight to descend, and a second mode of operation wherein line non-slippage relative to the first element thereby blocks descending of the first weight, the first element being a first rotor having an extended surface to engage multiple wraps of the first line, and the second element is associated with the first element, the first rotor extended surface having two axially spaced generally conical portions, and a generally cylindrical portion intermediate said conical portions and wherein said first rotor has an axial through passage, and said second line passes through said passage.

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